REPORT DOCUMENTATION PAGE

Form Approved OMB NO. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
06-12-2007	Final Report	1-Aug-2004 - 31-Jul-2007

4. TITLE AND SUBTITLE
Algorithm Development and Application of High Order Numerical Methods for Shocked and Rapid Changing Solutions

5a. CONTRACT NUMBER
W911NF-04-1-0291

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
611102

6. AUTHORS
Chi-Wang Shu

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES
Brown University
Office of Sponsored Projects
Brown University
Providence, RI 02912 -

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSOR/MONITOR'S ACRONYM(S)
ARO

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
44494-MA.1

12. DISTRIBUTION AVAILABILITY STATEMENT
Approved for public release; Federal purpose rights

13. SUPPLEMENTARY NOTES
The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT
We have investigated high order finite difference weighted essentially non-oscillatory (WENO) schemes, finite volume WENO schemes and discontinuous Galerkin finite element methods, for solving partial differential equations with discontinuous or rapidly changing solutions. Algorithm development, analysis, implementation and applications have been carried out.

Research has been performed in all areas listed in the original proposal, and progress and results consistent with the original

15. SUBJECT TERMS
WENO scheme, discontinuous Galerkin method, fluid dynamics, high order numerical methods

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Chi-Wang Shu
U	U	U	SAR		19b. TELEPHONE NUMBER
					401-863-2549

Report Title

Final Report: Algorithm Development and Application of High Order Numerical Methods for Shockedand Rapid Changing Solutions

ABSTRACT

We have investigated high order finite difference weighted essentially non-oscillatory (WENO) schemes, finite volume WENO schemes and discontinuous Galerkin finite element methods, for solving partial differential equations with discontinuous or rapidly changing solutions. Algorithm development, analysis, implementation and applications have been carried out.

Research has been performed in all areas listed in the original proposal, and progress and results consistent with the original objectives have been obtained. There are 53 refereed journal publications (42 appeared, 11 accepted and to appear) resulting from this project.

These achievements have strengthened our objective to obtain powerful and reliable high order numerical algorithms and use them to solve convection dominated problems, especially those of army interest.

List of papers submitted or published that acknowledge ARO support during this reporting period. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

[1] Y.-X. Liu and C.-W. Shu,
Local discontinuous Galerkin methods for moment models
in device simulations: formulation and one dimensional results,
Journal of Computational Electronics, v3 (2004), pp.263-267.

[2] J. Qiu and C.-W. Shu,
Hermite WENO schemes for Hamilton-Jacobi equations,
Journal of Computational Physics, v204 (2005), pp.82-99.

[3] F. Li and C.-W. Shu,
Reinterpretation and simplified implementation of
a discontinuous Galerkin method for Hamilton-Jacobi equations,
Applied Mathematics Letters, v18 (2005), pp.1204-1209.

[4] Y. Xu and C.-W. Shu,
Local discontinuous Galerkin methods for nonlinear Schr\"{o}dinger
equations,
Journal of Computational Physics, v205 (2005), pp.72-97.

[5] S. Chen, W. E and C.-W. Shu,
The heterogeneous multiscale method based on the discontinuous
Galerkin method for hyperbolic and parabolic problems,
Multiscale Modeling and Simulation: A SIAM Interdisciplinary Journal,
v3 (2005), pp.871-894.

[6] Z. Xu and C.-W. Shu,
Anti-diffusive flux corrections for high order finite difference
WENO schemes,
Journal of Computational Physics, v205 (2005), pp.458-485.

[7] Y. Xing and C.-W. Shu,
High order finite difference WENO schemes with the exact conservation
property for the shallow water equations,
Journal of Computational Physics, v208 (2005), pp.206-227.

[8] F. Filbet and C.-W. Shu,
Approximation of hyperbolic models for chemosensitive movement,
SIAM Journal on Scientific Computing, v27 (2005), pp.850-872.

[9] J. Qiu and C.-W. Shu,
A comparison of troubled-cell indicators for
Runge-Kutta discontinuous Galerkin methods using weighted essentially
nonoscillatory limiters,
SIAM Journal on Scientific Computing, v27 (2005), pp.995-1013.

[10] Y. Xu and C.-W. Shu,
Local discontinuous Galerkin methods for two classes of two-dimensional nonlinear wave equations,
Physica D, v208 (2005), pp.21-58.

[11] S. Zhang, Y.-T. Zhang and C.-W. Shu,
Multistage interaction of a shock wave and a strong vortex,
Physics of Fluids, v17 (2005), article number 116101.

[12] F. Filbet, Y. Guo and C.-W. Shu,
Analysis of the relativistic Vlasov-Maxwell model in an interval,
Quarterly of Applied Mathematics, v63 (2005), pp.691-714.

[13] Z. Xu and C.-W. Shu,
Anti-diffusive high order WENO schemes for Hamilton-Jacobi equations,
Methods and Applications of Analysis, v12 (2005), pp.169-190.

[14] J. Qiu, B.C. Khoo and C.-W. Shu,
A numerical study for the performance of the Runge-Kutta
discontinuous Galerkin method based on different numerical fluxes,
Journal of Computational Physics, v212 (2006), pp.540-565.

[15] P. Zhang, S.C. Wong and C.-W. Shu,
A weighted essentially non-oscillatory
numerical scheme for a multi-class traffic flow model on an
inhomogeneous highway,
Journal of Computational Physics, v212 (2006), pp.739-756.

[16] J. Carrillo, I. Gamba, A. Majorana and C.-W. Shu,
2D semiconductor device simulations by WENO-Boltzmann
schemes: efficiency, boundary conditions and comparison to Monte
Carlo methods,
Journal of Computational Physics, v214 (2006), pp.55-80.

[17] Y. Xing and C.-W. Shu,
High order well-balanced finite difference WENO schemes for a class
of hyperbolic systems with source terms,
Journal of Scientific Computing, v27 (2006), pp.477-494.

[18] Y. Xing and C.-W. Shu,
High order well-balanced finite volume WENO schemes and
discontinuous Galerkin methods for a class of hyperbolic systems
with source terms,
Journal of Computational Physics, v214 (2006), pp.567-598.

[19] Y. Xing and C.-W. Shu,
A new approach of high order well-balanced finite volume WENO
schemes and discontinuous Galerkin methods for a class of
hyperbolic systems with source terms,
Communications in Computational Physics, v1 (2006), pp.100-134.

[20] S. Gottlieb, D. Gottlieb and C.-W. Shu,
Recovering high order accuracy in WENO computations of steady
state hyperbolic systems,
Journal of Scientific Computing, v28 (2006), pp.307-318.

[21] C.-S. Chou and C.-W. Shu,
High order residual distribution conservative finite difference WENO
schemes for steady state problems on non-smooth meshes,
Journal of Computational Physics, v214 (2006), pp.698-724.

[22] K. Kremeyer, K. Sebastian and C.-W. Shu,
Computational study of shock mitigation and drag reduction by pulsed energy lines,
AIAA Journal, v44 (2006), pp.1720-1731.

[23] L. Yuan and C.-W. Shu,
Discontinuous Galerkin method based on non-polynomial
approximation spaces,

Journal of Computational Physics, v218 (2006), pp.295-323.

[24] Z. Xu and C.-W. Shu,
Anti-diffusive finite difference WENO methods for shallow
water with transport of pollutant,
Journal of Computational Mathematics, v24 (2006), pp.239-251.

[25] Y.-T. Zhang, C.-W. Shu and Y. Zhou,
Effects of shock waves on Rayleigh-Taylor instability,
Physics of Plasmas, v13 (2006), article number 062705.

[26] Q. Zhang and C.-W. Shu,
Error estimates to smooth solutions of Runge-Kutta discontinuous
Galerkin method for symmetrizable systems of conservation laws,
SIAM Journal on Numerical Analysis, v44 (2006), pp.1703-1720.

[27] Y. Xing and C.-W. Shu,
Application of high order well-balanced schemes to a class of
hyperbolic systems with source terms,
Boletin de la Sociedad Espanola de Matematica Aplicada,
v34 (2006), pp.69-80.

[28] S. Zhang, Y.-T. Zhang and C.-W. Shu,
Interaction of a shock wave with an oblique vortex pair:
shock dynamics and mechanism of sound generation,
Physics of Fluids, v18 (2006), article number 126101.

[29] M.J. Caceres, J.A. Carrillo, I. Gamba, A. Majorana and C.-W. Shu,
DSMC versus WENO-BTE: a double gate MOSFET example,
Journal of Computational Electronics, v5 (2006), pp.471-474.

[30] Y.-X. Liu and C.-W. Shu,
Local discontinuous Galerkin methods for moment models in device simulations: Performance assessment and two dimensional results,
Applied Numerical Mathematics, v57 (2007), pp.629-645.

[31] S. Zhang and C.-W. Shu,
A new smoothness indicator for the WENO schemes and its
effect on the convergence to steady state solutions,
Journal of Scientific Computing, v31 (2007), pp.273-305.

[32] Y. Cheng and C.-W. Shu,
A discontinuous Galerkin finite element method for
directly solving the Hamilton-Jacobi equations,
Journal of Computational Physics, v223 (2007), pp.398-415.

[33] J. Shen, C.-W. Shu and M. Zhang,
High resolution schemes for a hierarchical size-structured model,
SIAM Journal on Numerical Analysis, v45 (2007), pp.352-370.

[34] C.-S. Chou and C.-W. Shu,
High order residual distribution conservative finite difference WENO
schemes for convection-diffusion steady state problems on non-smooth meshes,
Journal of Computational Physics, v224 (2007), pp.992-1020.

[35] Y. Xu and C.-W. Shu,
Error estimates of the semi-discrete local discontinuous Galerkin

method for nonlinear convection-diffusion and KdV equations,
Computer Methods in Applied Mechanics and Engineering, v196 (2007), pp.3805-3822.

[36] Y.-J. Liu, C.-W. Shu, E. Tadmor and M. Zhang,
Non-oscillatory hierarchical reconstruction for central and finite volume schemes,
Communications in Computational Physics, v2 (2007), pp.933-963.

[37] Y. Xia, Y. Xu and C.-W. Shu,
Efficient time discretization for local discontinuous Galerkin methods,
Discrete and Continuous Dynamical Systems -- Series B, v8 (2007), pp.677-693.

[38] S. Chen, W. E, Y.-X. Liu and C.-W. Shu,
A discontinuous Galerkin implementation of a domain decomposition method for kinetic-hydrodynamic coupling multiscale problems in gas dynamics and device simulations,
Journal of Computational Physics, v225 (2007), pp.1314-1330.

[39] S. Noelle, Y. Xing and C.-W. Shu,
High order well-balanced finite volume WENO schemes for shallow water equation with moving water,
Journal of Computational Physics, v226 (2007), pp.29-58.

[40] Y. Xia, Y. Xu and C.-W. Shu,
Local discontinuous Galerkin methods for the Cahn-Hilliard type equations,
Journal of Computational Physics, v227 (2007), pp.472-491.

[41] J. Shen, C.-W. Shu and M. Zhang,
A high order WENO scheme for a hierarchical size-structured population model,
Journal of Scientific Computing, v33 (2007), pp.279-291.

[42] J. Cheng and C.-W. Shu,
A high order ENO conservative Lagrangian type scheme for the compressible Euler equations,
Journal of Computational Physics, v227 (2007), pp.1567-1596.

Number of Papers published in peer-reviewed journals: 42.00

(b) Papers published in non-peer-reviewed journals or in conference proceedings (N/A for none)

Number of Papers published in non peer-reviewed journals: 0.00

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts): 0

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts): 0

(d) Manuscripts

[1] J. Cheng and C.-W. Shu,
A high order accurate conservative remapping method on staggered meshes,
Applied Numerical Mathematics, to appear.

[2] F. Li and C.-W. Shu,
A local-structure-preserving local discontinuous Galerkin
method for the Laplace equation,
Methods and Applications of Analysis, to appear.

[3] Y. Cheng and C.-W. Shu,
A discontinuous Galerkin finite element method for time dependent
partial differential equations with higher order derivatives,
Mathematics of Computation, to appear.

[4] Y. Xu and C.-W. Shu,
A local discontinuous Galerkin method for the Camassa-Holm
equation,
SIAM Journal on Numerical Analysis, to appear.

[5] J.-M. Qiu and C.-W. Shu,
Convergence of Godunov-type schemes for scalar conservation laws
under large time steps,
SIAM Journal on Numerical Analysis, to appear.

[6] Y.-J. Liu, C.-W. Shu, E. Tadmor and M. Zhang,
Central discontinuous Galerkin methods on overlapping cells
with a non-oscillatory hierarchical reconstruction,
SIAM Journal on Numerical Analysis, to appear.

[7] L. Yuan and C.-W. Shu,
Discontinuous Galerkin method for a class of elliptic
multi-scale problems,
International Journal for Numerical Methods in Fluids, to appear.

[8] Y. Lu, S.C. Wong, M. Zhang, C.-W. Shu and W. Chen,
Explicit construction of entropy solutions for the Lighthill-Whitham-Richards
traffic flow model with a non-smooth flow-density relationship,
Transportation Research Part B, to appear.

[9] Y. Liu, C.-W. Shu and M. Zhang,
Strong stability preserving property of
the deferred correction time discretization,
Journal of Computational Mathematics, to appear.

[10] S. Curtis, R.M. Kirby, J.K. Ryan and C.-W. Shu,
Post-processing for the discontinuous Galerkin method
over non-uniform meshes,
SIAM Journal on Scientific Computing, to appear.

[11] C.-W. Shu,
High order weighted essentially non-oscillatory schemes for
convection dominated problems,
SIAM Review, to appear.

[12] L. Huang, S.C. Wong, M. Zhang, C.-W. Shu and W.H.K. Lam,
A reactive dynamic user equilibrium model for pedestrian flows:
a continuum modeling approach,

submitted to Transportation Research Part B.

[13] J.-M. Qiu and C.-W. Shu,
Convergence of high order finite volume weighted essentially non-oscillatory
scheme and discontinuous Galerkin method for
nonconvex conservation laws,
submitted to SIAM Journal on Scientific Computing.

[14] Y.-J. Liu, C.-W. Shu, E. Tadmor and M. Zhang,
L^2 stability analysis of the central discontinuous Galerkin method
and a comparison between the central and regular
discontinuous Galerkin methods,
submitted to ESAIM: Mathematical Modelling and Numerical Analysis ($M^{2}AN$).

[15] Y. Lu, S.C. Wong, M. Zhang and C.-W. Shu,
The entropy solutions for the
Lighthill-Whitham-Richards traffic flow model with a discontinuous
flow-density relationship,
submitted to Transportation Science.

[16] W. Wang, X. Li and C.-W. Shu,
The discontinuous Galerkin method for the multiscale modeling of dynamics of crystalline solids,
submitted to Multiscale Modeling and Simulation: A SIAM Interdisciplinary Journal.

Number of Manuscripts: 16.00

Number of Inventions:

Graduate Students

NAME	PERCENT_SUPPORTED
Yingda Cheng	0.50
Ling Yuan	0.90
FTE Equivalent:	**1.40**
Total Number:	**2**

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Chi-Wang Shu	0.10	No
FTE Equivalent:	**0.10**	
Total Number:	**1**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period:	0.00
The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:......	0.00
The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:......	0.00
Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):......	0.00
Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:......	0.00
The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense	0.00
The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:......	0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Shanqin Chen
Zhengfu Xu
Ching-Shan Chou
Yulong Xing
Ling Yuan
Yingda Cheng
Jingmei Qiu

Total Number: **7**

Names of other research staff

NAME	PERCENT_SUPPORTED

FTE Equivalent:

Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Final Report of ARO Grant W911NF0410291

Algorithm Development and Application of High Order Numerical Methods for Shocked and Rapid Changing Solutions

Chi-Wang Shu
Division of Applied Mathematics
Brown University
Providence, RI 02912
E-mail: shu@dam.brown.edu

August 1, 2004 to July 31, 2007

1. Foreword

We have investigated high order finite difference weighted essentially non-oscillatory (WENO) schemes, finite volume WENO schemes and discontinuous Galerkin finite element methods, for solving partial differential equations with discontinuous or rapidly changing solutions. Algorithm development, analysis, implementation and applications have been carried out. These achievements have strengthened our objective to obtain powerful and reliable high order numerical algorithms and use them to solve convection dominated problems, especially those of army interest.

4. Statement of the Problem Studied

The problems studied in this project involve numerically solving partial differential equations with either discontinuous or rapidly changing solutions. These include the so-called "convection dominated" cases, such as the hyperbolic equations, parabolic equations with small viscosities (e.g. high Reynolds number Navier-Stokes equations), KdV type equations with small dispersions (small third derivative terms), time-dependent bi-harmonic equations and equations with hyper-viscosity (small fourth or higher even derivative terms). Furthermore, we are interested in long time solutions of such equations with waves traveling a long distance, such as sound waves in aeroacoustics, vortex in helicopter rotor motions, etc. The requirement on numerical methods would thus be high order accuracy, low dissipation/dispersion errors over long time, and a clean and sharp shock resolution. An emphasis during the proposed work period will be on a study of efficiency, especially parallel efficiency of the proposed methods for various physical problems with methods of different orders of accuracy, and efficient multi-domain and adaptive methods. Finite difference

weighted essentially non-oscillatory (WENO) schemes, finite volume WENO schemes and discontinuous Galerkin finite element methods have been considered.

5. Summary of the Most Important Results

Research has been performed in all areas listed in the original proposal, and progress and results consistent with the original objectives have been obtained. There are 53 refereed journal publications (42 appeared, 11 accepted and to appear) resulting from this project, see Section 6 for a list of them.

An anti-diffusive flux correction for high order finite difference WENO schemes has been designed to sharpen contact discontinuities without affecting accuracy and has been applied to shallow water with transport of pollutant. This technique has also been generalized to Hamilton-Jacobi equations to sharpen corners.

High order finite difference and finite volume WENO schemes and discontinuous Galerkin methods with the exact conservation property for the shallow water equations and for a broader class of equations including the equations governing the chemosensitive movement have been developed. The more difficult situation of moving water steady state has also been addressed.

Recovery of high order accuracy in WENO computations of steady state hyperbolic systems has been studied.

A new smoothness indicator for the WENO schemes has been designed and its effect on the convergence to steady state solutions has been studied.

Multistage interaction of a shock wave and a strong vortex has been studied by using a high order accurate WENO solver.

Effects of shock waves on Rayleigh-Taylor instability have been studied using a very high order accurate WENO solver.

A weighted essentially non-oscillatory numerical scheme for a multi-class traffic flow model on an inhomogeneous highway has been developed.

Second order high resolution schemes and higher order WENO schemes for a hierarchical size-structured model have been developed and analyzed.

Computational study of shock mitigation and drag reduction by pulsed energy lines has been performed using a multi-domain WENO solver.

Two-dimensional semiconductor device simulations by WENO-Boltzmann schemes have been investigated in terms of efficiency, boundary conditions and comparison to Monte Carlo methods.

A Hermite type WENO scheme has been developed for solving Hamilton-Jacobi equations. Also for Hamilton-Jacobi equations, a reinterpretation and simplified implementation of a discontinuous Galerkin method have been given. A discontinuous Galerkin finite element method for directly solving the Hamilton-Jacobi equations has been designed and tested.

A high order residual distribution conservative finite difference WENO scheme

for steady state problems on non-smooth meshes has been developed, which has a smaller computational cost than finite volume schemes.

A non-oscillatory hierarchical reconstruction for central and finite volume schemes has been designed.

A high order ENO conservative Lagrangian type scheme for the compressible Euler equations has been developed.

Stable local discontinuous Galerkin methods have been designed for solving the nonlinear Schrödinger equations, the Kadomtsev-Petviashvili equation, the Zakharov-Kuznetsov equation, the Kuramoto-Sivashinsky equations, the Ito-type coupled KdV equations, and the Cahn-Hilliard type equations. Error estimates for some of these methods have been given.

A discontinuous Galerkin method based on non-polynomial approximation spaces has been developed and analyzed.

A comparison of troubled-cell indicators for Runge-Kutta discontinuous Galerkin methods using weighted essentially nonoscillatory limiters has been performed.

A numerical study for the performance of the Runge-Kutta discontinuous Galerkin method based on different numerical fluxes has been performed.

The heterogeneous multiscale method based on the discontinuous Galerkin method for hyperbolic and parabolic problems has been developed. A discontinuous Galerkin implementation of a domain decomposition method for kinetic-hydrodynamic coupling multiscale problems in gas dynamics and device simulations has been addressed.

A unified local discontinuous Galerkin method for moment models for semi-conductor device simulations has been developed, which is suitable for adaptive computations.

Efficient time discretization for local discontinuous Galerkin methods has been investigated.

Analysis of the relativistic Vlasov-Maxwell model in an interval has been performed.

6. Bibliography: refereed journal papers (appeared or accepted) which have quoted partial support by this grant

1. M.J. Caceres, J.A. Carrillo, I. Gamba, A. Majorana and C.-W. Shu, DSMC versus WENO-BTE: a double gate MOSFET example, Journal of Computational Electronics, v5 (2006), pp.471-474.

2. J. Carrillo, I. Gamba, A. Majorana and C.-W. Shu, 2D semiconductor device simulations by WENO-Boltzmann schemes: efficiency, boundary conditions and comparison to Monte Carlo methods, Journal of Computational Physics, v214 (2006), pp.55-80.

3. S. Chen, W. E, Y.-X. Liu and C.-W. Shu, A discontinuous Galerkin implementation of a domain decomposition method for kinetic-hydrodynamic coupling

multiscale problems in gas dynamics and device simulations, Journal of Computational Physics, v225 (2007), pp.1314-1330.

4. S. Chen, W. E and C.-W. Shu, The heterogeneous multiscale method based on the discontinuous Galerkin method for hyperbolic and parabolic problems, Multiscale Modeling and Simulation: A SIAM Interdisciplinary Journal, v3 (2005), pp.871-894.

5. J. Cheng and C.-W. Shu, A high order ENO conservative Lagrangian type scheme for the compressible Euler equations, Journal of Computational Physics, v227 (2007), pp.1567-1596.

6. J. Cheng and C.-W. Shu, A high order accurate conservative remapping method on staggered meshes, Applied Numerical Mathematics, to appear.

7. Y. Cheng and C.-W. Shu, A discontinuous Galerkin finite element method for directly solving the Hamilton-Jacobi equations, Journal of Computational Physics, v223 (2007), pp.398-415.

8. Y. Cheng and C.-W. Shu, A discontinuous Galerkin finite element method for time dependent partial differential equations with higher order derivatives, Mathematics of Computation, to appear.

9. C.-S. Chou and C.-W. Shu, High order residual distribution conservative finite difference WENO schemes for steady state problems on non-smooth meshes, Journal of Computational Physics, v214 (2006), pp.698-724.

10. C.-S. Chou and C.-W. Shu, High order residual distribution conservative finite difference WENO schemes for convection-diffusion steady state problems on non-smooth meshes, Journal of Computational Physics, v224 (2007), pp.992-1020.

11. S. Curtis, R.M. Kirby, J.K. Ryan and C.-W. Shu, Post-processing for the discontinuous Galerkin method over non-uniform meshes, SIAM Journal on Scientific Computing, to appear.

12. F. Filbet, Y. Guo and C.-W. Shu, Analysis of the relativistic Vlasov-Maxwell model in an interval, Quarterly of Applied Mathematics, v63 (2005), pp.691-714.

13. F. Filbet and C.-W. Shu, Approximation of hyperbolic models for chemosensitive movement, SIAM Journal on Scientific Computing, v27 (2005), pp.850-872.

14. S. Gottlieb, D. Gottlieb and C.-W. Shu, Recovering high order accuracy in WENO computations of steady state hyperbolic systems, Journal of Scientific Computing, v28 (2006), pp.307-318.

15. K. Kremeyer, K. Sebastian and C.-W. Shu, Computational study of shock mitigation and drag reduction by pulsed energy lines, AIAA Journal, v44 (2006), pp.1720-1731.

16. F. Li and C.-W. Shu, Reinterpretation and simplified implementation of a discontinuous Galerkin method for Hamilton-Jacobi equations, Applied Mathematics Letters, v18 (2005), pp.1204-1209.

17. F. Li and C.-W. Shu, A local-structure-preserving local discontinuous Galerkin method for the Laplace equation, Methods and Applications of Analysis, to appear.

18. Y.-J. Liu, C.-W. Shu, E. Tadmor and M. Zhang, Non-oscillatory hierarchical reconstruction for central and finite volume schemes, Communications in Computational Physics, v2 (2007), pp.933-963.

19. Y.-J. Liu, C.-W. Shu, E. Tadmor and M. Zhang, Central discontinuous Galerkin methods on overlapping cells with a non-oscillatory hierarchical reconstruction, SIAM Journal on Numerical Analysis, to appear.

20. Y. Liu, C.-W. Shu and M. Zhang, Strong stability preserving property of the deferred correction time discretization, Journal of Computational Mathematics, to appear.

21. Y.-X. Liu and C.-W. Shu, Local discontinuous Galerkin methods for moment models in device simulations: formulation and one dimensional results, Journal of Computational Electronics, v3 (2004), pp.263-267.

22. Y.-X. Liu and C.-W. Shu, Local discontinuous Galerkin methods for moment models in device simulations: Performance assessment and two dimensional results, Applied Numerical Mathematics, v57 (2007), pp.629-645.

23. Y. Lu, S.C. Wong, M. Zhang, C.-W. Shu and W. Chen, Explicit construction of entropy solutions for the Lighthill-Whitham-Richards traffic flow model with a non-smooth flow-density relationship, Transportation Research Part B, to appear.

24. S. Noelle, Y. Xing and C.-W. Shu, High order well-balanced finite volume WENO schemes for shallow water equation with moving water, Journal of Computational Physics, v226 (2007), pp.29-58.

25. J.-M. Qiu and C.-W. Shu, Convergence of Godunov-type schemes for scalar conservation laws under large time steps, SIAM Journal on Numerical Analysis, to appear.

26. J. Qiu, B.C. Khoo and C.-W. Shu, A numerical study for the performance of the Runge-Kutta discontinuous Galerkin method based on different numerical fluxes, Journal of Computational Physics, v212 (2006), pp.540-565.

27. J. Qiu and C.-W. Shu, Hermite WENO schemes for Hamilton-Jacobi equations, Journal of Computational Physics, v204 (2005), pp.82-99.

28. J. Qiu and C.-W. Shu, A comparison of troubled-cell indicators for Runge-Kutta discontinuous Galerkin methods using weighted essentially nonoscillatory limiters, SIAM Journal on Scientific Computing, v27 (2005), pp.995-1013.

29. J. Shen, C.-W. Shu and M. Zhang, High resolution schemes for a hierarchical size-structured model, SIAM Journal on Numerical Analysis, v45 (2007), pp.352-370.

30. J. Shen, C.-W. Shu and M. Zhang, A high order WENO scheme for a hierarchical size-structured population model, Journal of Scientific Computing, v33 (2007), pp.279-291.

31. C.-W. Shu, High order weighted essentially non-oscillatory schemes for convection dominated problems, SIAM Review, to appear.

32. Y. Xia, Y. Xu and C.-W. Shu, Efficient time discretization for local discontinuous Galerkin methods, Discrete and Continuous Dynamical Systems – Series B, v8 (2007), pp.677-693.

33. Y. Xia, Y. Xu and C.-W. Shu, Local discontinuous Galerkin methods for the Cahn-Hilliard type equations, Journal of Computational Physics, v227 (2007), pp.472-491.

34. Y. Xing and C.-W. Shu, High order finite difference WENO schemes with the exact conservation property for the shallow water equations, Journal of Computational Physics, v208 (2005), pp.206-227.

35. Y. Xing and C.-W. Shu, High order well-balanced finite difference WENO schemes for a class of hyperbolic systems with source terms, Journal of Scientific Computing, v27 (2006), pp.477-494.

36. Y. Xing and C.-W. Shu, High order well-balanced finite volume WENO schemes and discontinuous Galerkin methods for a class of hyperbolic systems with source terms, Journal of Computational Physics, v214 (2006), pp.567-598.

37. Y. Xing and C.-W. Shu, A new approach of high order well-balanced finite volume WENO schemes and discontinuous Galerkin methods for a class of hyperbolic systems with source terms, Communications in Computational Physics, v1 (2006), pp.100-134.

38. Y. Xing and C.-W. Shu, Application of high order well-balanced schemes to a class of hyperbolic systems with source terms, Boletin de la Sociedad Espanola de Matematica Aplicada, v34 (2006), pp.69-80.

39. Y. Xu and C.-W. Shu, Local discontinuous Galerkin methods for nonlinear Schrödinger equations, Journal of Computational Physics, v205 (2005), pp.72-97.

40. Y. Xu and C.-W. Shu, Local discontinuous Galerkin methods for two classes of two-dimensional nonlinear wave equations, Physica D, v208 (2005), pp.21-58.

41. Y. Xu and C.-W. Shu, Error estimates of the semi-discrete local discontinuous Galerkin method for nonlinear convection-diffusion and KdV equations, Computer Methods in Applied Mechanics and Engineering, v196 (2007), pp.3805-3822.

42. Y. Xu and C.-W. Shu, A local discontinuous Galerkin method for the Camassa-Holm equation, SIAM Journal on Numerical Analysis, to appear.

43. Z. Xu and C.-W. Shu, Anti-diffusive flux corrections for high order finite difference WENO schemes, Journal of Computational Physics, v205 (2005), pp.458-485.

44. Z. Xu and C.-W. Shu, Anti-diffusive high order WENO schemes for Hamilton-Jacobi equations, Methods and Applications of Analysis, v12 (2005), pp.169-190.

45. Z. Xu and C.-W. Shu, Anti-diffusive finite difference WENO methods for shallow water with transport of pollutant, Journal of Computational Mathematics, v24 (2006), pp.239-251.

46. L. Yuan and C.-W. Shu, Discontinuous Galerkin method based on non-polynomial approximation spaces, Journal of Computational Physics, v218 (2006), pp.295-323.

47. L. Yuan and C.-W. Shu, Discontinuous Galerkin method for a class of elliptic multi-scale problems, International Journal for Numerical Methods in Fluids, to appear.

48. P. Zhang, S.C. Wong and C.-W. Shu, A weighted essentially non-oscillatory numerical scheme for a multi-class traffic flow model on an inhomogeneous highway, Journal of Computational Physics, v212 (2006), pp.739-756.

49. Q. Zhang and C.-W. Shu, Error estimates to smooth solutions of Runge-Kutta discontinuous Galerkin method for symmetrizable systems of conservation laws, SIAM Journal on Numerical Analysis, v44 (2006), pp.1703-1720.

50. S. Zhang and C.-W. Shu, A new smoothness indicator for the WENO schemes and its effect on the convergence to steady state solutions, Journal of Scientific Computing, v31 (2007), pp.273-305.

51. S. Zhang, Y.-T. Zhang and C.-W. Shu, Multistage interaction of a shock wave and a strong vortex, Physics of Fluids, v17 (2005), article number 116101.

52. S. Zhang, Y.-T. Zhang and C.-W. Shu, Interaction of a shock wave with an oblique vortex pair: shock dynamics and mechanism of sound generation, Physics of Fluids, v18 (2006), article number 126101.

53. Y.-T. Zhang, C.-W. Shu and Y. Zhou, Effects of shock waves on Rayleigh-Taylor instability, Physics of Plasmas, v13 (2006), article number 062705.